AD694347

Technical Research Report 1158

AD

HUMAN FACTORS RESEARCH IN COMMAND INFORMATION PROCESSING SYSTEMS-- SUMMARY OF RECENT STUDIES

Seymour Ringel, James D. Baker,
Michael H. Strub, and Loren L. Kensinger

SUPPORT SYSTEMS RESEARCH DIVISION

U. S. Army
Behavioral Science Research Laboratory

July 1969

27

Technical Research Report 1158

AD

HUMAN FACTORS RESEARCH IN COMMAND INFORMATION PROCESSING SYSTEMS--SUMMARY OF RECENT STUDIES

Seymour Ringel, James D. Baker,
Michael H. Strub, and Loren L. Kensinger

SUPPORT SYSTEMS RESEARCH DIVISION
Joseph Zeidner, Chief

U. S. ARMY BEHAVIORAL SCIENCE RESEARCH LABORATORY

Office, Chief of Research and Development
Department of the Army

Room 239, The Commonwealth Building
1320 Wilson Boulevard, Arlington, Virginia 22209

July 1969

Army Project Number
2Q024701A723

Command Systems

FOREWORD

Technological advancements have led to increased speed, mobility, and destructive power of military operations. To permit commanders to make tactical decisions consistent with rapid change and succession of events, information on military operations must be processed and used more effectively than ever before. To meet this need, the Army is developing automated systems for receipt, processing, storage, retrieval, and display of different types and vast amounts of military data. There is a concomitant requirement for research to determine how human abilities can be utilized to enable the command information processing systems to function with maximum effectiveness.

The entire research effort is responsive to requirements of RDT&E Project 2Q024701A723, "Human Performance in Military Systems," FY 1969 Work Program, and to special requirements of the Assistant Chief of Staff for Force Development, The U. S. Army Computer Systems Command, the Assistant Chief of Staff for Intelligence, and the Combat Developments Command. Research is conducted by two BESRL Work Units, Tactical Information Processing and Tactical Operations Systems.

To conduct back-up research in close rapport with TOS development, BESRL in September 1967 established a Command Systems Field Branch within USAREUR. The BESRL Branch in Germany conducts on-the-spot human performance research in support of the development of the Tactical Operations System and its concepts. At the same time, the involvement of BESRL's research scientists in TOS development and design verification enables the early identification of field-oriented human factor problems and promotes experimentation calculated to afford solutions of direct operational applicability.

The present publication provides a synopsis of BESRL research on tactical information processing and on tactical operations systems, including principal findings and their application to operational problems. Studies completed prior to the beginning of FY 1967 were summarized in BESRL Technical Research Report 1145, "Human factors research in command information processing systems," March 1966.

J. E. UHLANER, Director
U. S. Army Behavioral Science
Research Laboratory

HUMAN FACTORS RESEARCH IN COMMAND INFORMATION PROCESSING SYSTEMS--SUMMARY OF RECENT STUDIES

BRIEF

Requirement:

To provide an overview of BESRL's human factors research program in command information processing systems, with emphasis on accomplishments since March 1966. Objectives in brief:

Tactical Information Processing (TIP). To assist commanders and their staffs in information assimilation and decision making and to develop techniques for the efficient processing and use of information by operational personnel in tactical situations.

Tactical Operations Systems (TOS). To maximize the effectiveness of command information processing systems through the most efficient use of human abilities.

Procedure:

BESRL's manned systems research in this area is directed toward the enhancement of human performance and facilitation of man-machine interaction in relation to total system effectiveness. It involves experimentation with various configurations of system components, considering interactions and tradeoffs.

The end products--immediate or ultimate--are scientific findings on human capabilities and performance under varying conditions within the system. The findings have implications for systems design, development, and operational use. The present report--the result of a review of recent research activities--presents such end products in abbreviated form, providing sufficient information on a given study to show the basis for the findings reported.

The implications stated below must be regarded as tentative, since development of the Tactical Operations System (TOS) continues and modifications are still being made. Some of the statements derive from strong indications noted in initial studies. Continuing research will probe more deeply the reasons for the results obtained.

Implications of Recent Studies:

1. Implication: The cathode ray tube (CRT) should be used for TOS output as well as input.

Supporting research: For message composition, electronic devices (CRT with typewriter keyboard) were found to be superior to electro-mechanical devices (teletypewriter). Advantages of the CRT held for output procedures as well as input.

2. Implication: The present TOS transform process should be changed rather than merely aided. Now, the action officer selects a format, fills it out, and gives it to the UIOD operator who copies the message on the CRT screen. The action officer may be able to fill in the format directly on the CRT screen.

Supporting research: In a field study, incorrect formats were selected for 22% of incoming messages. A specially developed device to structure selection did not improve performance.

3. Implication: Much information now displayed in graphic and symbolic form requiring manual preparation should be presented in alpha-numeric form on computer-generated displays. Proper use of TOTES could reduce the time spent by staff officers in preparing summary reports.

Supporting research: In an experiment comparing alpha-numeric presentation (TOTES) with graphic (map symbols), amount of information assimilated, accuracy of decision, and degree of confidence in the report were not affected by mode of presentation. Results held under time restriction as well as with unlimited time allowance.

4. Implication: The present method of rating spot reports should be simplified. Research in the area points up the potential of subjective probabilities as a useful substitute.

Supporting research: The present schema, requiring both a 6-point accuracy rating (multidimensional) and a 6-point reliability rating (unidimensional) was found to be too time-consuming to be profitable. Even with job-aids to flow chart the process of arriving at an evaluation, the G2 did not have time to use the rating schema. Neither speed nor accuracy improved. The potential usefulness of subjective estimates of the probability that a report is correct was indicated in preliminary studies of agreement among officers in rank ordering messages according to perceived utility. The usefulness of direct estimates of probability is being pursued by BESRL's Field Branch.

5. Implication: The development of an overall system criterion for TOS must await the determination of how well the system meets the specific needs of different users.

Supporting research: Preliminary analysis of critical information requirements and varying and unique needs of users as well as the fact that many TOS subsystems are still in the formative stage led to the stated conclusion.

6. Implication: Attitude toward automation on the part of TOS users will have a significant effect on the ultimate acceptance of TOS.

Supporting research: BESRL's Field Branch is conducting surveys in the Seventh Army to assess initial attitudes of users toward TOS and change in attitude after experience with TOS equipment. Results will aid a program to promote understanding and acceptance of the computerized information processing system.

7. Implication: A data base structure may be shared by at least the three highest echelons of command, and by armored and infantry units.

Supporting research: These elements were in agreement as to the types of information commonly needed in army field exercises.

8. Implication: Computer aids to tactical decision making may yield substantial payoff in combat situations about which the data are typically conflicting and of low reliability. Information which is highly reliable may be evaluated as fast and as accurately by man as by machine.

Supporting research: Subjects were found to recognize complex patterns of activity when they occurred frequently (in 80% of the information displays) but not when occurrence was relatively infrequent.

HUMAN FACTORS RESEARCH IN COMMAND INFORMATION PROCESSING SYSTEMS--
SUMMARY OF RECENT STUDIES

CONTENTS

HUMAN FACTORS RESEARCH IN COMMAND INFORMATION PROCESSING SYSTEMS--SUMMARY OF RECENT STUDIES

The Command Systems program of the U. S. Army Behavioral Science Research Laboratory is directed toward solving problems associated with information processing and decision making by commanders and their staffs. Research focuses on one or more aspects of events which occur from the time a commander receives his mission until he completes it. This chain of events is the system within which command decisions are formulated and executed--a tactical operations system within which tactical information processing is performed.

The Command Systems program is divided into two work units. Research efforts which focus on such information processing aspects as the rapid and accurate input and assimilation of information are conducted by the Tactical Information Processing (TIP) work unit. Efforts which emphasize aspects of the total system such as allocation of functions to man and equipment and system information requirements fall within the Tactical Operations System (TOS) work unit. The present report traces research progress from the beginning of FY 1967 to the present. During this period 23 projects were completed or are now in progress.

LABORATORY AND FIELD APPROACHES

Human information processing and decision making may be observed on an abstract level in the laboratory or as operational procedures in the field. To provide a research capability responsive to requirements for varying degrees of operational simulation, the Command Systems program has established both laboratory and field approaches.

The laboratory efforts are conducted within an environment designated as SIMTOS (simulated tactical operations system). Within this environment, experiments are based on simulations of tactical operations systems. System equipment is similar to that now used by the 7th Army TOS Development Group in Germany. The major devices are cathode ray tubes and teletypewriters linked to a 32k computer with disk and tape storage capability consisting of three disk and two tape drives. Computer-driven random access slide projectors, maps, and acetate overlays for recording permanent information complement the SIMTOS.

To provide direct field contact for operational applications of laboratory findings and early identification of field-oriented human factor problems which should be investigated in the laboratory, the BESRL Command Systems program maintains a field branch in Heidelberg, Germany, residence of the 7th Army TOS. Here it is possible to observe at first hand the problems associated with the performance of personnel in an automated information system and the evaluation and fielding of the system.

The maintenance of both laboratory and field facilities provides not only a wide and flexible research base but also a means of cross-validating research findings. For example, there may be a question whether a laboratory finding will hold up in the field; or a field observation may need to be subjected to rigorous laboratory test.

REVIEW OF BESRL RESEARCH--TACTICAL INFORMATION PROCESSING

Techniques for Rapid and Accurate Information Updating

Screening. An automated information system such as TOS receives vast amounts of information from many and varied sources. The information varies widely in content, form, and degree of completeness. Further, the information often affects several different staff groups. The raw data require a great deal of handling and processing by man and equipment. Incoming messages must first be screened for system relevance. Irrelevant information must not be allowed to enter the system. The problem of screening has received little attention to date. Exercise observations do not yield information about screening. The scenarios used in command post and field training exercises employ only relevant messages. Ambiguous data, purposefully deceitful data, and data without historical continuity are rarely included.

Transform. The process of transforming information for input requires taking the typically unconstrained free-English text that characterizes a manual system message and converting it to equivalent symbolic notation, entered in specific format fields (particular alpha-numeric character locations) for the particular class of information in the computer's data base that is to be acted upon. All information contained in the TOS data base must be entered and retrieved via formats. If the appropriate format is not selected, the information is typically rejected by the system, thereby introducing delays in updating the data base. In some instances, however, the information can be processed through the system using an inappropriate format. In that case, the information is, to all intents and purposes, irretrievable; it will not be where it should be in the the data base.

Research on the transform operation in TOS has been carried out by the field branch in Germany (1). A job-aid was developed in an attempt to improve the accuracy of format selection by action officers who must decide which format is appropriate for each incoming message. Fourteen subjects processed 47 messages. The main concern was the method of format selection: half the subjects used the job-aid while the other half used a "menu" type listing of available formats. The job-aid developed was ineffective in improving the accuracy of format selection. The more important finding, however, was that an incorrect format was selected 22% of the time. Thus, the transformation operation represents a definite bottleneck in the system; during periods of heavy message traffic, information may wait in queue for a considerable length of time before it is entered into the system. Research is continuing to develop effective aids which hopefully will yield error rates considerably below 22%.

Input. Once the information is recorded in the appropriate format, it is entered into the system. A variety of input devices exist. In response to a request by the U. S. Army Computer Systems Command, the merits of electronic message composition devices (such as a cathode ray tube with typewriter keyboard) and electro-mechanical (teletypewriter) devices were compared (2). The advantages and potential of an electronic message composition device were found to outweigh those of a teletypewriter. Findings supported the procedure in the present TOS in Germany, in which all information is entered into the system via electronic rather than a teletypewriter device.

Information Assimilation and Transfer

At present, the principal computer-driven equipment employed in TOS is the cathode ray tube with typewriter keyboard (input) and the teletypewriter (output). These devices transmit mainly alpha-numeric information. The question arises as to what extent information assimilation would be degraded by the translation of map symbols and other information to alphanumeric equivalents. If the degradation is negligible, then much of the information now displayed symbolically on maps could be stored alphanumerically in the computer. If the degradation is severe, either the process of generating map symbols must remain manual or the Army must wait for computer state-of-the-art to develop a capability of adequate reliability that can be operated at an acceptable cost.

A recent in-house experiment dealt with decision making using updated graphic vs alpha-numeric information (3). Subjects were required to decide in which of three sectors the enemy was building up for an attack. Information was displayed via both map symbols and alpha-numeric TOTES. Neither decision accuracy, amount of information assimilated, nor degree of confidence was affected by the method of presentation (graphic vs alpha-numeric).

A second study entitled "Time Stress and Information Format in a Decision Making Task" (4) was similar to the above experiment except that 1) a time restriction of 20 seconds per slide was imposed (the above study imposed no restriction), and 2) subjects alternated between graphic and alpha-numeric problems. Results were consistent with findings of the earlier study which indicated no difference in decision performance between alpha-numeric and graphic presentation of data. These results are encouraging since they suggest that much of the information now being posted manually on maps in symbolic form may be stored in the computer, making possible automatic updating of enemy and friendly unit identifications and locations.

This conclusion was supported in a study conducted by the field branch (5). This study dealt with implications of the Command Systems in-house research for displays in tactical information processing. One of the conclusions is that the potential of TOTE-type displays for facilitating information presentation and assimilation appears substantial,

especially of TOTES which can be generated by an automated data processing system. Proper use of such TOTES could reduce reliance on situation maps and save the time of staff officers who prepare summary reports. Subsequent research will attempt to determine more precisely what information now in map and symbol format may be converted to TOTES and summary tables with no loss in performance.

Effective Aids in the Decision Process

Research in this area is aimed at discovering how decision making ability may be enhanced or aided by factors or conditions within the decision environment. Two such conditions, amount of information and knowledge of results or feedback, were investigated in a study entitled "Timeliness and Accuracy in a Sequential Decision Making Task" (6). While accuracy varied directly with amount of information, feedback had little effect on either accuracy or confidence in performance; performance accuracy was 57% under the no feedback condition and 65% under the feedback condition. It was suggested that the failure of feedback to produce large changes in accuracy of decision may be attributable to the nature of the experimental task. Subjects who received feedback may not have been able to relate this information to any systematic procedure for arriving at a decision.

There was also indication that lack of confidence in his ability to make accurate decisions may cause the decision maker to delay taking action even when he could make an accurate decision on the basis of the information available. This finding suggests that, along with techniques to enhance the quality of decisions, techniques are needed to enhance confidence in those decisions.

A second study entitled "Confidence and Posterior Probabilities in an Interpretative Decision Task (7)" is in progress. In the interpretation task, a sequence of nine slides depicted a build-up of enemy forces. Each slide represented an independent sighting of equipment. The subject's task was to estimate probabilities concerning the type of unit building up and to commit himself to action when he was reasonably convinced that he had enough information for a decision. Variables of interest included a computer aid and two work methods. Time to decision (number of slides), accuracy of decision, and confidence estimates (subjective probability) were the measures to be analyzed. Preliminary findings indicate that: 1) a simple computer aid (furnishing cumulative data about enemy equipment sighted) relieved the subjects of time-consuming clerical chores, reduced errors, and thereby resulted in improved performance; and 2) a work technique which requires that subjects consider all relevant information in a complex task improved performance over individual "common sense" approaches.

The field branch in Germany has directed much of its attention to developing aids for the evaluation of G2 spot reports. The standard NATO schema requires that each spot report contain two ratings, an accuracy rating on a six-point complex multidimensional scale and a reliability

rating on a six-point unidimensional scale. At first, research effort was concentrated on job-aids (8). Two job-aids were developed, one following the Field Manual text, the other incorporating suggestions from the faculty at the G2 Intelligence School located in Oberammergau, Germany. The job-aids were variants of a decision process flow chart consisting of a series of yes-no questions leading to the appropriate evaluations. When the results of job-aided groups were compared with results of control groups using no job-aids, no differences were found either in speed or accuracy of evaluations. This finding, coupled with conversation with school faculty and data from student questionnaires, led to the following conclusion: A job-aid is not the solution to the G2's evaluation problems; he does not have time for such a rating schema even when the necessary decision process is flow charted for him.

However, the above conclusion does not imply that an underlying evaluation process does not operate. A second study (9) demonstrated a definite utility of spot reports. Intelligence school students were asked to select from among 16 spot reports the most important set of four messages, followed by the second and third sets of four. The results yielded significant agreement among students. If students do rank order spot reports according to a perceived utility but do not have time to use a job-aid, perhaps the evaluation process could be improved by changing the rating schema itself. At present, the field branch in Germany is conducting research to test the hypothesis that many G2 personnel implicitly assign a likelihood to the information in a spot report and then convert this to one of the six categories of rating accuracy (10). If this hypothesis is correct, much information is lost in the process of translating the subjective likelihood evaluation into the objective rating schema. Research is now in progress to determine the extent to which G2 personnel can assign subjective probabilities to the reliability of source and accuracy of a report and whether these probabilities correlate with the six-point scale currently used.

REVIEW OF BESRL RESEARCH--TACTICAL OPERATIONS SYSTEMS

Individual and System Performance Measures

BESRL's simulated tactical operations system (SIMTOS) as described earlier represents only a "first-cut" simulation. Data from the first human performance experiment in which 21 field grade officers (4 colonels, 17 lieutenant colonels) served as subjects are now being analyzed. The results of these analyses will influence the direction of subsequent SIMTOS research.

A report describing a projected five-year program for the SIMTOS facility has been drafted (11). The report consists of two main sections: the first describes the present simulation capabilities of SIMTOS; the second is a discussion of future SIMTOS designed to meet additional requirements as simulation fidelity is increased to include many highly complex capabilities such as real-time updating and staff interaction.

In the first SIMTOS experiment (12), recently completed, each subject was informed that he was to take the part of a G3 of a mechanized infantry division on alert status in assembly areas near the town of Kulmbach, Germany. The subject was given the Corps Ops Order (less Annexes) to provide him with a general understanding of the defensive situation, the capabilities of his command, and the nature of the enemy threat.

The scenario was designed to provide three measures of decision making behavior. In the first portion of the scenario, the subject is requested to draw avenues of approach and key terrain on the situation map and report his recommended form of defense. In the second portion, he is to develop a course of action within the division sector and allocate maneuver elements to the echelons of defense--general outpost, forward defense area forces, and reserve forces--and to specify the type of resistance by each echelon of defense--delay, screen, defend. In the third portion of the scenario, the subject is to develop the graphic portion of his defense order to include location of

General outpost
Combat outpost
Brigade boundaries and coordinating points
Battalion positions of forward defense area forces
Reserve forces
Visualized allowable penetrations
Division-directed blocking positions
Task organization
Mission to subordinate units

The subject was to obtain information by phoning his request to the operator of a user input/output device (a role taken by the experimenter) who located the information in the data base and sent it to the subject via CRT, typewriter, or slide projector. The principal data were the subject's answers, his information requests, and time of his requests. The results of the experiment will provide preliminary guidelines for establishment of an overall system performance criterion and identifications of critical information requirements.

The establishment of an overall system criterion is not expected to be an easy task. A report in progress (13) concerned with user oriented criteria for the TOS points out that the system is in an evolutionary phase and that criteria change with each new stage of development. For example, while the present version of the TOS in Germany deals only with typewriter message output, second generation versions may place greater emphasis on the cathode ray tube as an output device. Further, a computer-generated situation display is likely to be used in the next generation TOS. The report succinctly states the difficulty of determining system criteria under varying display devices:

> The practical consequence of this evolutionary development of means of displaying TOS - generated information is that the rate and nature of information assimilation by TOS users can be expected to vary with the nature of the display being used. Further, exactly how information is assimilated under various display conditions and the relative efficiency and effectiveness of different techniques remain unknown at this time.

A second problem encountered in outlining a general approach to the user criterion problem is that a system such as the TOS has several users. The extent to which men interact directly with the system delineates the several types of user. The type of user who interacts most closely with the TOS is the UIOD operator. He is there because the TOS is there. His job did not exist in the manual system. His interaction is largely a mechanical one: He types and sends messages already composed by the staff action officer, and he receives messages sent by the computer. Performance variables relevant to this type of equipment operator are already covered in existing human factors literature.

A second type of user, whose duties existed before the advent of the TOS, is the staff action officer. Before the TOS, this individual performed his information dissemination role without use of ADP. Now, he serves as the first flexible interplay point between the TOS and the military staff. His job, the mechanics of which vary substantially from staff element to staff element (for example, from G2 to G3), has two major functions. He converts staff information needs to a form that the TOS can understand (via TOS message formats). He also has the task of inserting data to the TOS and extracting information from it to fulfill staff needs. What he does has direct impact on the TOS and upon other staff officers using the TOS.

A third type of user falls into a broader category, which includes senior staff officers and commanders who utilize TOS generated information in military operations. These officers are the ultimate TOS users who work as skilled professionals performing executive operations. A good deal of their activity is more art than straight-forward science and is difficult to assess quantitatively.

The difficulty of deriving a criterion satisfactory to many users is apparent: How develop an overall criterion which is sensitive not only to how the system is being used but also to which staff element is using it? Any general measurement approach must be geared to take account of the unique situations which TOS users will present to the system.

One of the very real problems which the field branch brings to the attention of the in-house research staff deals with the impact of automation on Seventh Army users. In the research-development-production-distribution gamut, those in the research environment may lose sight of

the fact that users of new systems may not be as intimately acquainted with them as are the research scientists who devise them. User reaction to a new product must be favorable--a successful research program may be nullified by a user's refusal to accept innovations.

In a report now being prepared by the field branch (14), it is pointed out that when the TOS equipment is delivered to the users and incorporated into the conduct of a field exercise, it will provide a rare opportunity to measure the initial impact of automation on staff functions at three echelons of operation--army, corps, division. It will also provide opportunity to measure a factor critical in predicting a system's success or failure, namely, user acceptability.

The field branch has begun a series of attitude and user observation surveys in the form of questionnaires administered to members of the Seventh Army. The initial questionnaire was administered before the user was exposed to TOS. These data mainly provide base-line attitude measures concerned with the user's preconceived notions regarding the potential advantages--or, in some cases, disadvantages--of automation in a tactical setting. Upon completion of a TOS orientation/training course, the user was again surveyed. The assumption here was that the user should have, upon completion of the course, an understanding of the system which should be reflected in more definitive notions about the relative advantages, or disadvantages, of operating in an automated environment.

Since the initial increment of TOS includes only enough equipment to supply one corps and two divisions, the remaining corps and two divisions surveyed were not involved in the TOS orientation/training program. Having a non-user group at two essentially equated echelons provides the opportunity to assess changes in attitude as a function of new experiences encountered or occurring simply with the passage of time. This non-user control group will be resurveyed to obtain these data. The user group will also be resurveyed at approximately the same time, after members have had rather extensive on-the-job training experience with the system, to obtain measures of changes in general attitude as well as specific measures of their assessment of specific TOS features and implementation procedures.

From the overall results of the survey, it will be possible to determine what may be expected in terms of initial user attitude toward automation and to detect any change in attitude following familiarity with automated equipment. In addition, results from the survey will delineate shortcomings of the present TOS in Germany. Knowledge of deficiencies will provide an empirical foundation for the assignment of retrofit priorities and provide a basis for making design decisions concerned with future United States Army command and control systems such as TOS-75.

Another report in progress concerns a flow chart model of the TOS system (15). This model will depict critical human functions such as screening messages for TOS relevancy and selecting appropriate formats. The model will also delineate those functions which will be automated,

such as standing requests for information. The model will serve two main purposes: to focus useful small-scale subsystem experiments in relation to the overall system, and to describe the impact of parameters at each node (subsystem operation) of the total system. In the latter function, the model should be particularly useful for evaluations of TOS effectiveness.

Commander's Information Requirements

The introduction of automated equipment may increase the flow of incoming information to such an extent as to overwhelm the commander and his staff. To preclude such an eventuality, research has been conducted and is in progress to determine the categories of information which are most critical to the commander and his staff, to determine how specific information needs vary according to the TOS user, and to derive logically the problems which could result when the evaluation process occurs within the TOS. Answer to these questions will not only facilitate information flow within the automated system but also insure a viable manual back-up system as well.

In a report, "Human factors experimentation within a tactical operations system (TOS)" (16), which contains a brief description of the Seventh Army TOS now under development and the activities of the BESRL field branch in Germany, the early endeavors in establishing initial information areas are discussed. As a result of the work of the system analysts of the TOS Development Group (a group made up of military and civilian personnel from the then Automatic Data Field Systems Command, Fort Belvoir) and the efforts of a sizable number of civilian contractors, five critical functional information areas were given first priority for automation.

However, it was difficult to insure that field commanders would not be buried in data in the five areas, albeit all relevant data.[1] Thus, a further delineation is necessary to establish message priorities within these areas. One of the first tasks undertaken by the BESRL field branch,

---

[1] An individual largely responsible for the fact that the development of the TOS is taking place in an operational setting (Seventh Army in Europe) is the former Deputy Director, Defense Research and Engineering, the Honorable Eugene G. Fubini. In his opening address to the Second Congress on the Information System Sciences, Dr. Fubini warned against this very situation. In his words: "And so, facing the users today is another problem. It is the problem of trying to tell you technologists what it is we want you to do . . . We have some partial answers. One answer, a negative answer, is that we don't want you to be squirrels when you build equipment for us. We don't want you to store things just because you think that maybe we'll need them. To store and retrieve all available data is just wrong. Collect only what you can use. I know it is easy to say but difficult to implement. But still, if somebody comes in and tells me, 'You see, I can collect everything, retrieve everything, and display anything.' I say, 'I don't want it'." (Information System Sciences: Proceedings of the Second Congress. (J. Spiegel and D. Walker, eds.) Washington, D. C. Spartan Books, Inc. 1965, page 1.)

therefore, was to identify and validate the types of information being handled by the various tactical operations centers. An in-progress study, Information requirements for field army users" (17), was designed to determine how specific types of information needed by TOS users vary as a function of 1) the particular staff element [G2, G3, Chemical, Biological, Radiological element (CBRE), or Fire Support Coordination element (FSCE)]; 2) the echelon of command (army, corps, division); and 3) the type of unit involved (Armor or Infantry).

Eighty-six experienced staff officers in the United States Seventh Army, including the principal staff officers in each section, responded to a questionnaire containing 61 types of information commonly appearing in staff exercise journals. Of the items, 34 dealt with enemy information, 16 with friendly unit information, and 11 with CBRE information about friendly and enemy units. Staff officers could check up to 30 of the items on the basis of their importance during field exercises. While all analyses of the data have not yet been completed, preliminary results indicate that:

1. The staff element in which an officer serves is far and away the most important determinant of what he feels is of importance.

2. Echelon of command has no effect upon the importance attached to different classes of information.

3. By and large, whether users are in an armored or infantry division has either no or little practical impact upon what users judge to be important items of information.

4. On the whole, G2 and G3 personnel checked all 30 items denoting kinds of information important in field exercises, indicating that G2 and G3 staff action officers needed more types of information during exercises than did FSCE, which checked roughly 20 items, or CBRE, which checked about 15.

In an unpublished summary of the Seventh Army manual system base-line data, the field branch recently discovered material bearing on the above findings. The summary data showed that of the messages coming into a TOC approximately 48% was intended for the G2, 37% for the G3, and 15% for the FSCE/CBRE. These traffic proportions were the same at all echelons--that is, echelon of command had no effect. Thus, if need should arise to assign a priority of the effort to be expended toward examining particular classes of information, G2 information should rank high.

Further data relevant to the last point appeared in a recently published field branch study, "Certitude judgments in an operational environment," (18). All messages filed by two divisions of one corps during seven days of a field exercise were examined. It was found that spot reports accounted for 70% of all G2 messages. Since G2 messages constitute about half of all TOC traffic, and since the preponderance of the G2's messages are spot reports, clearly this is a class of information to which considerable attention should be paid.

It merits comment that division is the lowest echelon now serviced by TOS. Consequently, all information coming into a division TOC has been only manually processed and thus requires further handling before it can be input to TOS. Since the bulk of this traffic will be made up of G2 spot reports, which nearly always originate from troops in contact and long range patrols, the application of source data collection techniques to the handling of G2 spot reports has the potential of providing the biggest single improvement to date in the conduct of tactical operations.

The fact that G2 information is so important was one factor which prompted a thorough investigation of the G2 spot reports. The study was also prompted by concern over the extent to which reliability and accuracy ratings were being omitted from the G2 spot reports. TOS requires the presence of both ratings or it will reject the message. It was found that if standard forms were not provided and a spot report had to be filed on plain paper, it did not contain the necessary reliability and accuracy ratings. It was also found that three-fourths of all G2 spot reports were given the same rating (high reliability, high accuracy).

It was in response to these findings that the G2 spot report job-aid, discussed earlier, was developed. It may be recalled that the job-aid was found to be ineffective. On the basis of the present and earlier discussion concerning G2 spot reports, it may be concluded that <u>the crucial importance of G2 information, the failure to assign ratings when standard forms were unavailable, and the tendency to give the same ratings to all incoming messages suggest reevaluation of the entire rating schema</u>.

The nature of the mission also may dictate the critical information needs. When the data from the first SIMTOS experiment are analyzed, it will be interesting to compare the types of information requested most frequently by the field grade officer subjects with the types of information indicated as most crucial by the staff officers who responded to the survey of information requirements for field army users. The survey was conducted without regard to any specific mission, whereas in the SIMTOS study the subjects were G3's. Each subject was instructed in a mission statement that he was to <u>defend</u>--prevent enemy from penetrating west of "line red." Thus, while the survey and exercise data suggest that G2 data are most critical, the SIMTOS study may well find that friendly unit information (G3) was requested most frequently. Such a result would further underscore the difficulty of developing an overall system criterion, since the measure would have to take into account not only the particular user but also the particular mission.

To support research concerned with the flow of tactical information across the sequence of actions in making and executing a military decision, a tactical decision information network was developed (19). Decision points were defined, decision makers specified, and information requirements delineated. These data were then organized in the form of function flow block diagrams and associated data input sheets which

collectively constitute the network. The network provides a framework within which comprehensive tactical decision situations (offensive or defensive) in a nuclear or non-nuclear combat environment can be developed for use in research in decision making.

Man-Computer Decision Making

Thus far, the computer and its associated equipment have been discussed as an information storage and retrieval system. Certain of the critical information requirements of the commander and the lines of communication from the field to him have been established. What remains unknown are many of the processes which intervene between the commander's assimilation of the information and his issuing of orders. One of the processes is the aggregation of a considerable amount of information of varying degree of accuracy and reliability as a basis for an overall evaluation--of an enemy threat, for example. Models exist which will optimally combine or aggregate many items of information provided man can first quantify the uncertainty of each item. Thus, it is important to know man's ability to evaluate items of information. Several questions have been asked concerning this ability. What is the relationship between a man's performance and his confidence in the accuracy of his performance? The answer to this question would provide evidence toward determining if there are consistent tendencies to overestimate or underestimate the uncertainty associated with individual items of information. A second question may be asked: Is any one way of expressing uncertainty, such as betting odds, any better than another, such as subjective probabilities? The computer is indifferent to the form of the uncertainty expression; the form is easily convertible to any metric by the computer. If one response form is better than any other (yields probabilities which more closely approximate truth), the use of that form will reflect man's best ability to quantify the uncertainty of information, and the computer aggregation of these uncertainties will provide the best evaluation possible. A third question is: What is man's ability to aggregate many items of information into an overall evaluation and does this ability vary with the degree of uncertanity of the information? If there are certain situations in which man performs optimally in aggregating many items of information, then the cost of constructing elaborate and expensive computer programs to evaluate information for these situations may not be warranted. Another question is: How well can man recognize patterns of activity, and what is the need for computer aids which will provide automated pattern recognition? Again, if there are situations in which man is perceptive and flexible in his ability to discern patterns within a sequence of events, it may not be necessary to automate this aspect of the decision process for these situations.

With regard to the first question concerning the extent to which feelings of confidence or certitude appropriately reflect a person's information assimilation performance, two in-house experiments were conducted: "Relation of Certitude Judgments to Characteristics of Updated Symbolic Information" (20) and "Subjective Probability and Decision

Behavior in a Perceptual Task" (21). As is often the case in research, these studies uncovered many problems in attempting to relate confidence and accuracy. The first is one of measurement. In the first study, it was found that, because of the different metrics, it was not feasible to determine quantitatively the degree of conformity or whether the confidence judgments were predominately overestimates or underestimates of accuracy. In neither study were subjects provided with feedback (knowledge of results) during the experiment. It might be argued that in the absence of feedback, a consistent difference between confidence and accuracy reflects a constant error which would disappear if the subject could see that he was overestimating or underestimating by the same amount each time. Another problem encountered in attempting to relate confidence and accuracy is how accuracy is defined. The second study tested subjects' ability to identify the number of flag symbols on a display which was presented for a very brief period. They also indicated the degree of confidence in the accuracy of their identifications. The number of symbols varied from 4 to 24. It was concluded that subjects typically overestimated their performance. This conclusion was reached on the basis of comparing confidence estimates with the percent of the time subjects identified the <u>exact</u> number of symbols. No credit was given for being close. However, fitting linear models relating numerousness to estimated number of symbols revealed that the model with unit slope and intercept equal to zero, using the actual number to predict the estimates, accounted for 99 percent of the variance of the estimates around zero. If credit were given for being close, it might be concluded that subjects typically underestimated their performance. From the varying effects of differences in metric, feedback, and criterion definition, it must be concluded that the relationship between confidence and accuracy will not be easily determined.

The question of response form and ability to aggregate information has been investigated in an in-house study, "Probability Estimates in Tactical Decision Making" (22). Form of response was compared by having subjects make estimates both in the form of odds and as subjective probabilities. Ability to aggregate was observed by comparing human estimates of posterior probabilities with computer-aggregated posterior probabilities. The study also used a wide range of probability levels, making it possible to determine performance at varying levels of information uncertainty. Data are now being analyzed.

The final question dealt with human ability to perceive patterns within a sequence of events. A recently conducted in-house study, "Perception of Military Event Patterns in a Two-Choice Prediction Task" (23), was designed to observe subjects' ability to recognize second-order patterns, i.e., patterns in which the next enemy activity, attack or rest, is predictable on the basis of his last two activities. Subjects exhibited a high degree of pattern recognition when the patterns were occurring 80% of the time but very little pattern recognition when patterns were occurring only 68% of the time. Evidently, when there is considerable pattern interference as at the 68% level, pattern recognition by the computer would be a useful aid to the decision maker. However, for patterns occurring at

the 30%-level or above, computer assistance may not be necessary, since men appear to be capable of recognizing second-order patterns at these levels.

CONCLUSIONS AND IMPLICATIONS

This review has been an attempt to describe briefly and to integrate the last three years of research within the laboratory and field branch of the Command Systems program. BESRL Technical Research Report 1145, "Human Factors Research in Command Information Processing Systems" (24) describes research conducted prior to this period.

Based on the research described in the present report, a number of conclusions and implications may be drawn. The following statements were judged to be the most important _operational_ implications to be derived from the research program. Statements are made without qualification in order to provide a clear indication of the implications. They should not be interpreted as final in any respect. Army Tactical Operations Systems are only in the incubation period. Therefore, conclusions reached on the basis of TOS and TOS-related research must be regarded as tentative. With these precautions in mind, the following recommendations are offered:

1. _CRT's should be used as output devices_. The TOS currently uses the CRT primarily as an input device. Many of the advantages which favor the CRT over the typewriter as an input device hold true for the CRT as an output device as well.

2. _Efforts should be directed toward changing rather than aiding the present TOS transform process_. The present method of having an action officer select a format, fill it out, and hand it to a UIOD operator to be recopied onto the CRT screen is redundant. The possibility of having the action officer call up a format and fill it in directly on the CRT screen should be explored.

3. _Much graphic and symbolic information currently presented on manually prepared displays should be presented in alpha-numeric form on computer generated displays_. Recent laboratory comparisons of assimilation of graphic vs alpha-numeric information have revealed that subjects perform as well with alpha-numeric as with symbolic displays of information.

4. _Efforts should be directed toward changing rather than aiding the present two-part spot report rating schema_. The present rating schema is complicated and observers do not have time to use a job aid. They may be better able to express their evaluations by using subjective probabilities rather than the present scales.

5. It is too early to determine a single overall system criterion; a multiple-criterion approach would be better for present experimentation. The TOS is in a state of evolution; there is no assurance that the present man-machine configuration will not change. The TOS-75 system may be radically different from the present TOS in Germany. Also, the fact that there are many different TOS users, each with his own unique needs, suggests that criteria should be established for individual sets of users and that an overall criterion should not be developed until the system has achieved more maturity.

6. Attitude toward automation on the part of TOS users will have a significant effect on ultimate acceptance of TOS. A program for coping with possible initial biases or prejudices toward TOS due mainly to a lack of understanding of and therefore a distrust of such "gadgets" as computerized information processing systems should be developed.

7. Echelon of command (army, corps, division), type of unit (armored vs infantry), and assignment (Corps A vs Corps B) will most likely be able to share the same data base structure. These groups were in agreement as to the types of information commonly needed in army field exercises.

8. Potential computer aids to decision processes (such as threat evaluation) may be most advantageous for situations in which the data are of low diagnostic value. Subjects do not recognize complex patterns except when they occur frequently. On the other hand, information which is highly reliable (such as friendly unit information) may be evaluated as well by man as by machine. For these situations, the payoff may not be sufficient to warrant the cost of developing programs to evaluate such information. For other situations, such as the evaluation of intelligence data which are typically conflicting and of low reliability, a much larger payoff may be derived from the development of computer aids to assist the tactical decision making of the commander.

LITERATURE CITED

1. Electronic and electro-mechanical message composition devices. Unpublished report.

2. Baker, J. D. (BESRL), and D. J. Mace and J. M. McKendry (HRB-Singer, Inc.). The transform operation in TOS: An assessment of the human component. BESRL Technical Research Note 212. July 1969.

3. Vicino, F. L. and S. Ringel. Decision making with updated graphic vs alpha-numeric information. BESRL Technical Research Note 178. November 1966. (AD 647 623)

4. Green, C. G. Time stress and information format in a decision making task. BESRL Research Memorandum 68-4. April 1968.

5. McKendry, J. M. and D. J. Mace (HRB-Singer, Inc.), and J. D. Baker (BESRL). Implications of BESRL research for displays in tactical information processing. BESRL Technical Research Report 1156. January 1969.

6. Hammer, C. H. Timeliness and accuracy in a sequential decision making task. BESRL Technical Research Note 162. October 1965. (AD 625 223)

7. Confidence and posterior probabilities in an interpreter decision task. In progress.

8. The effect of a job-aid on the evaluation of G2 spot reports. In progress.

9. Factors relating to perceived utility of G2 spot reports. In progress.

10. The application of subjective probabilities in the evaluation of G2 spot reports. In progress.

11. Krumm, R. L. (Bunker-Ramo Corp.). Studies of tactical military decision making: I. Design of a simulated tactical operations system (SIMTOS). BESRL Research Study. In progress.

12. Studies of tactical military decision making: III. Development of a scenario of operations planning. In progress.

13. McKendry, J. M. and D. J. Mace (HRB-Singer, Inc.), and J. D. Baker (BESRL). User oriented criteria for the TOS. In progress.

14. An assessment of the impact of automation on Seventh Army users. In progress.

15. TOS flow chart model. In progress.

16. Baker, J. D. Human factors experimentation within a tactical operations system (TOS) environment. BESRL Research Study 68-4. October 1968.

17. Information requirements for field army users. In progress.

18. Baker, J. D. (BESRL), and J. M. McKendry and D. J. Mace (HRB-Singer, Inc.). Certitude judgments in an operational environment. BESRL Technical Research Note 200. November 1968. (AD 681 232)

19. Ryan, T. G. (Bunker-Ramo Corp.). Studies of tactical military decision making: II. An information network aid to scenario development. BESRL Research Study 69-11. In preparation.

20. Andrews, R. S., F. L. Vicino, and S. Ringel. Relation of certitude judgments to characteristics of updated symbolic information. BESRL Technical Research Note 194. April 1968. (AD 831 288)

21. Andrews, R. S. and R. F. Boldt. Subjective probability and decision behavior in a perceptual task. BESRL Research Memorandum 68-7. May 1968.

22. Kensinger, L. L. Probability estimates in tactical decision making. In progress.

23. Strub, M. H. Perception of military event patterns in a two-choice prediction task. In progress.

24. Ringel, S., F. L. Vicino, and R. S. Andrews. Human factors research in command information processing systems. BESRL Technical Research Report 1145. March 1966. (AD 634 313)

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
*Tactical Operations System (TOS)						
Command information processing systems						
Summary research						
*SIMTOS						
Laboratory facilities						
*Human factors research-field approach						
*Methodology						
Automation						
Subsystem operation						
Decision making						
Computer aids						

Unclassified

Security Classification